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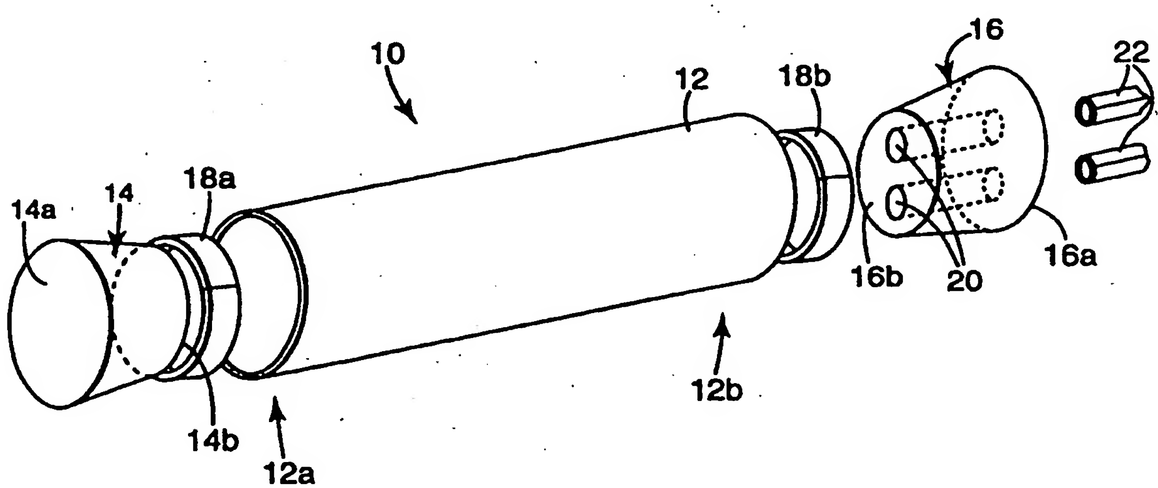

(57) Abstract

A sealed closure (10) includes a tube (12), stoppers disposed in the ends of the tube (12), and a void space defined in the tube (12) between the stoppers (14, 16). The stoppers (14, 16) define holes (20) for accommodating the passage of cables (32, 34) therethrough, which cables (32, 34) are spliced in the void space. The interfaces between the tube (12) and the stoppers (14, 16) and between the stoppers (14, 16) and the cables (32, 34) are sealed by exposing the interfaces to heat generated from a susceptor material positioned in the interfaces. The susceptor material is exposed to an oscillating magnetic field for heat generation. The heat fuses the stoppers (14, 16), the susceptor material, the tube (12) and the cables (32, 34).

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BONDED SEALED CLOSURE SYSTEMS AND METHODS

Background of the Invention

The present invention generally relates to systems and methods for bonded sealed closures for protecting cables, such as communications, electronics, and telecommunication cables and, more particularly, to bonded sealed closures, so bonded by thermal fusion bonding, creating seals that protect the cables from environmental exposure that could impact the integrity of the cables.

Several sealed closures and methods for sealed closure have typically been employed to seal portions of cables, such as electrical and telecommunications cables having conductor elements and a low surface energy outer jacket. Although the terms "conductor" and "conductor elements" are used herein, it is to be understood that the terms refer here to not only electrical conductors, but also to any and all other materials and paths for communication, such as optic fibers and others. The low surface energy outer jacket of these cables is typically comprised of polyethylene, polypropylene, or an inclusive co-polymer, which forms a protective sheath around the conductor elements. This low surface energy outer jacket serves as a barrier to contact of the conductor elements with environmental conditions, such as moisture and other conditions that may affect the conductor elements. If the integrity of the outer jacket of these cables is compromised, however, for example, by wear damage, removal to access the conductor elements, or other conditions, the outer jacket does not sufficiently seal the conductor elements from the environment. As may be expected, the integrity of the cables, including their useful life expectancy, their operation, their strength, and their other characteristics, may be affected if the seal of the outer jacket is not repaired or replaced.

Closures for cables have been particularly important in locations of cable splices. With conventional sealed closures for these purposes, an outer covering or housing has been placed over portions of the cable in locations of exposed conductor elements of the splice. The covering or housing has then been sealed with the remaining outer jacket of the cables to seal the conductor elements within the covering or housing. Typically, the covering or housing has been

sealed with the outer jacket by pressure seal and/or by sealants. Pressure seals have been formed by shrinking or collapsing the covering or housing against the low surface energy outer jacket of the cables, thereby sealing the covering or housing with the outer jacket. Sealants, such as mastics or gels, have been employed to expand to fill voids between the covering or housing and the outer jacket of the cables or to adhere to the covering or housing and the outer jacket, in each case forming seals between the covering or housing and the outer jacket.

In cases of pressure sealing and sealing by sealants, heating has at times been employed to effect the shrinking or collapsing, expanding or adhering, as the case may be. The heating for these purposes has typically been either by resistive, inductive, external torch, or chemical process. In resistive heating, wires of high resistance are located in the vicinity of the desired heat effect. Electrical current is fed to the wires, and the resistance of the wires generates heat. The current may be varied to obtain the desired heating. In induction heating, electromagnetic elements are placed in the vicinity of the desired heat effect and a magnetic field is oscillated around the electromagnetic elements. The electromagnetic elements in the magnetic field generate heat for the bonding. In chemical process heating, chemicals which react to generate a suitable heat of reaction are placed in the vicinity where heating is desired. The chemicals are then reacted, generating heat effects.

Coverings or housings of typical sealed closures have been either structurally rigid or flexible. In the case of rigid structure, the coverings or housings have been either collapsed onto the low surface energy outer jacket of the cables or voids between the covering or housing and the outer jacket have been filled by sealants which expand or adhere. With the structurally flexible coverings or housing, the coverings or housings have generally been shrunk to seal against the outer jacket of the cables and sealants either have or have not been used in connection therewith.

Several problems are presented by the conventional coverings or housings and the conventional sealants as employed for sealed splice closures. A significant problem is that the sealing is by pressure seal, not necessarily bonding or fusion of materials. Clearly, a bonding or fusing of materials in forming seals would tend to provide improved sealability over mere pressure

seals. Furthermore, at least in the case of flexible coverings or housings, each covering or housing has been supported by a structural core over which the covering or housing is placed in order that the cables and splice may be placed within the structural core and, thus, also within the covering or housing. This has been necessary because the covering or housing, alone, is not easily stretched to place over the cables and splice. The structural core has been removed from around the cables and splice and from within the covering or housing prior to contracting the covering or housing against the outer jacket of the cables. The structural core, as removed from around the cable and from within the covering or housing, is treated as refuse. Once the structural core has been so removed, the covering or housing contracts against the outer jacket of the cables. Thus, another problem with use of the conventional structural core is that its removal requires extra steps in the sealed closure implementation process. Even more, once the structural core is removed, the sealed closure is not rigid, whereas a rigid structure may be particularly desirable in some instances, for example, when the closure is used to seal cable splices.

Also of significance with respect to conventional coverings or housings has been that it has not been feasibly possible to bond polyethylene or similar polymeric materials to rubber in order to create the seals of the coverings or housings. This has been the case, at least in part, because the interface (or bond line) between the polymeric materials and rubber in such instances has not been sufficiently accessed and heated. Furthermore, excessive temperatures necessary to fuse rubber have typically resulted in distortion or de-polymerization of the polymeric material. Thus, applying heat through the rubber or the polymeric material to reach and heat the interface has not been suitable.

Therefore, what is needed is a system and method for sealing closure of cable splices, which system and method provide advantages of bonded or fused sealing, ease of use, low cost, field-use simplicity, and others. Further, what is needed is a system and method for bonding rubber and polymeric material for forming the seals.

Summary of the Invention

Embodiments of the present invention, accordingly, provide systems and

methods for sealing closure of cable splices. The embodiments provide advantages of bonded sealing, ease of use, low cost, field-use simplicity, and others.

An embodiment of the invention is a sealed closure. The sealed closure comprises a tube having a first end and a second end, a first stopper disposed in the first end, wherein the tube and the first stopper are bonded together by heat generated from a first binder interposed between the tube and the first stopper when the binder is exposed to an oscillating magnetic field, second stopper disposed in the second end and defining at least one hole extending longitudinally therethrough, wherein the tube and the second stopper are bonded together from heat generated from a second binder interposed between the tube and the second stopper when the binder is exposed to an oscillating magnetic field, and at least two cables, each of which extends through one of the at least one holes, and which cables are electrically connected together in the interior of the tube between the first and second stoppers. The cables and the surfaces defining the holes are bonded together from heat generated from third binders interposed between the cables and the surfaces of the respective holes when the third binders are exposed to an oscillating magnetic field.

Another embodiment of the invention is a kit for sealing closures. The kit comprises a tube having a first end and a second end, a first stopper capable of being disposed in the first end of the tube, a second stopper capable of being disposed in the second end of the tube, the second stopper defining at least two holes extending longitudinally therethrough such that at least two cables may be extended through the at least two holes and be electrically connected together in the interior of the tube, and a plurality of binders capable of being interposed between the tube and the first stopper, between the tube and the second stopper, and between the surface of each of the at least two holes and the at least two cables extending through the at least two holes, such that upon exposure to an oscillating magnetic field, the binders generate sufficient heat to bond the tube to the first and second stoppers, and the cables to the surfaces of the holes through which the respective cables extend.

Yet another embodiment of the invention is a sealed closure. The sealed closure comprises a tube having a first end and a second end, a first stopper

disposed in the first end and defining at least one first hole extending longitudinally therethrough, wherein the tube and the first stopper are bonded together from heat generated from a first binder interposed between the tube and the first stopper when the binder is exposed to an oscillating magnetic field, a second stopper disposed in the second end and defining at least one second hole extending longitudinally therethrough, wherein the tube and the second stopper are bonded together from heat generated from a second binder interposed between the tube and the second stopper when the binder is exposed to an oscillating magnetic field, and at least one first cable extending through the at least one first hole, and at least one second cable extending through the at least one second hole, which at least one first and second cables are electrically connected together in the interior of the tube between the first and second stoppers, wherein the at least one first and second cables and the surfaces defining the respective at least one first and second holes are bonded together from heat generated from third binders interposed between the at least one first and second cables and the surfaces defining the respective at least one first and second holes when the third binders are exposed to an oscillating magnetic field.

Another embodiment of the invention is a kit for sealing closures. The kit comprises a tube having a first end and a second end, a first stopper capable of being disposed in the first end of the tube, the first stopper defining at least one first hole extending longitudinally therethrough such that at least one first cable is capable of being extended through the at least one first hole, a second stopper capable of being disposed in the second end of the tube, the second stopper defining at least one second hole extending longitudinally therethrough such that at least one second cable is capable of being extended through the at least one second hole and of being electrically connected to the at least one first cable in the interior of the tube, and a plurality of binders capable of being interposed between the tube and the first stopper, between the tube and the second stopper, and between the surface of each of the at least one first and second holes and the respective at least one first and second cables extending through the at least one first and second holes, such that upon exposure to an oscillating magnetic field, the binders generate sufficient heat to bond the tube to the first and second stoppers, and the at least one first and second cables to

the surfaces of the respective at least one first and second holes.

Yet another embodiment of the invention is a sealed closure. The sealed closure comprises a tube having a first open end and a second open end, at least two cables electrically connected together at a splice, wherein the cables are received into the first end of the tube such that the splice is within the interior of the tube, and wherein the tube and the at least two cables are bonded together from heat generated from a first binder wrapped around the cables and interposed between the cables and the tube when the binder is exposed to an oscillating magnetic field, and a plug disposed in the second end, wherein the tube and the plug are bonded together from heat generated from a second binder interposed between the tube and the plug when the binder is exposed to an oscillating magnetic field.

Another embodiment of the invention is a kit for sealing closures. The kit comprises a tube having a first open end and a second open end, at least two cables capable of being electrically connected together at a splice, and of being received into the first end of the tube such that the splice is within the interior of the tube, and wherein the tube and the at least two cables are capable of being bonded together from heat generated from a first binder wrapped around the cables and interposed between the cables and the tube when the binder is exposed to an oscillating magnetic field, and a plug capable of being disposed in the second end, wherein the tube and the plug are capable of being bonded together from heat generated from a second binder interposed between the tube and the plug when the binder is exposed to an oscillating magnetic field.

Yet another embodiment of the invention is a sealed closure. The sealed closure comprises a pipe having a first open end and a second open end, at least two cables electrically connected together at a splice, wherein the cables are received into the first end of the pipe such that the splice is within the interior of the pipe, and wherein the cables are wrapped in a flexible film member at the interface between the cables and the pipe, and first and second heat-shrink tube portions fitted over the respective first and second ends of the pipe, the flexible film member, the first and second pipe ends, and the first and second tube portions and bonded together, and the void space is sealed, from the application of heat thereto.

Another embodiment of the invention is a kit for sealing closures. The kit comprises a pipe having a first open end and a second open end, at least two cables capable of being electrically connected together at a splice, wherein the cables are capable of being received into the first end of the pipe such that the splice is within the interior of the pipe, and wherein the cables are capable of being wrapped in a flexible film member at the interface between the cables and the pipe, and first and second heat-shrink tube portions capable of being fitted over the respective first and second ends of the pipe. The flexible film member, the first and second pipe ends, and the first and second tube portions are capable of being bonded together, and the void space is sealed, from the application of heat thereto.

Another embodiment of the invention is a method of bonding polymeric material to rubber. The method includes the steps of placing the polymeric material in contact with the rubber so that there is a polymeric material/rubber interface, heating the polymeric material/rubber interface, and applying pressure to force the polymeric material towards the rubber.

Yet another embodiment of the invention is a system of bonding polymeric material to rubber. The polymeric material contacts the rubber at a polymeric material/rubber interface. The system includes means for heating the polymeric material/rubber interface and means for applying pressure to force the polymeric material towards the rubber.

Brief Description of the Drawings

Fig. 1 is an exploded, perspective view, with portions shown in phantom, of a splice closure apparatus according to embodiments of the present invention.

Fig. 2 is a perspective, partial cut-away, partial phantom view of a sealed splice closure formed by the splice closure apparatus of Fig. 1, according to embodiments of the present invention.

Fig. 3 is a cross-sectional end view taken along the line A-A of Fig. 2.

Fig. 4 is a perspective, vertically enlarged view of a susceptor composite binder material employable as a bondable insert part for electromagnetic bonding of sealed splice closures according to embodiments of the present invention.

Fig. 5 is a flow chart showing steps of a method for implementing the sealed splice closure of Figs. 1 and 2, according to embodiments of the present invention.

Fig. 6 is an elevational, cross-sectional view of an alternative sealed splice closure according to embodiments of the present invention.

Fig. 7 is a flow chart showing steps of a method for implementing the sealed closure of Fig. 6, according to embodiments of the present invention.

Fig. 8 is a partial, perspective view showing cables wrapped with a binder in another alternative sealed closure apparatus, according to embodiments of the present invention.

Fig. 9 is a perspective, partial cut-away view of another alternative sealed closure formed by the splice closure apparatus of Fig. 8, according to embodiments of the present invention.

Fig. 10 is a flow chart showing steps of a method for implementing the sealed closure of Figs. 8 and 9, according to embodiments of the present invention.

Fig. 11 is a perspective, partial cut-away view of another alternative sealed closure, according to embodiments of the present invention.

Fig. 12 is a partial perspective view showing cables wrapped with a flexible film in implementing the sealed closure of Fig. 11, according to embodiments of the present invention.

Fig. 13 is a flow chart showing steps of a method for implementing the sealed closure of Figs. 11 and 12, according to embodiments of the present invention.

Like numerals used for reference in the drawings refer to like elements.

Detailed Description of the Preferred Embodiment

Referring to Fig. 1, the reference numeral 10 refers, in general, to a splice closure apparatus. The splice closure apparatus 10 includes a tube 12 having first and second end portions 12a and 12b, respectively. The tube 12 has an inside diameter of adequate size to accommodate cables, such as telecommunications or electronics cables, for example, at a splice. The tube 12 is formed of a material that is impenetrable by environmental effects and conditions and that is capable of housing the cables. An example of the tube 12

is a rigid, low density pipe, having a low melting point, such as, for example, a polyethylene pipe, although other cylindrical-shaped materials can be substituted.

First and second stoppers 14 and 16 are provided to be inserted into the first and second end portions 12a and 12b, respectively, of the tube 12. The first and second stoppers 14 and 16 are each generally conical-shaped with flat ends 14a and 14b, and 16a and 16b, respectively. The flat ends 14b and 16b of the first and second stoppers 14 and 16, respectively, are smaller than the internal diameter of the tube 12. The flat ends 14a and 16a of the first and second stoppers 14 and 16, respectively, are larger than the internal diameter of the tube 12. The longitudinal lengths of the stoppers 14 and 16 between the flat ends 14a and 14b and the flat ends of 16a and 16b, respectively, are sufficient that the stoppers 14 and 16 may be pressed an adequate distance, for example, about 0.5 to about 6 inches, into the tube 12 at the end portions 12a and 12b, respectively, to retain the stoppers 14 and 16 positioned partially within the end portions 12a and 12b.

The stopper 14 is solid and has holes 20 extending longitudinally therethrough. The holes 20 have a diameter of adequate size to accommodate cables. The stoppers 14 and 16 are conventional and are formed of conventional materials, for example, rubber, such as ethylene/propylene diene monomers (EPDM), Santoprene™, including polypropylene/EPDM or polypropylene/butyl rubber, natural rubber, or other materials which are adequately bondable and provide adequate sealing and resilience upon bonding as herein later described. The holes 20 of the stopper 16 may be formed during molding or machining, as the case may be, of the stopper 16 or may be drilled or otherwise bored in a solid stopper like the stopper 14.

The splice closure apparatus 10 also includes binders 18a, 18b, and 22 comprised of materials that serve to bondingly seal adjacent parts of the splice closure apparatus 10. The binders 18a, 18b, and 22 may be solids, liquids, pastes, gels or other forms that are suitable for location between the adjacent parts and that provide suitable bonding of materials to form a seal. In an example of a solid, the binders 18a, 18b, and 22 may be formed as strips from sheets of solid, but flexible, binder materials. In this case, the strips are folded

into cylindrical shapes and placed into the tube 12 between the tube 12 and the stoppers 14 and 16, as is to be the case with the binders 18a and 18b, respectively, and placed into the holes 20, as is to be the case with the binders 22. As hereinafter detailed, the binders 22 encircle cables when placed within the holes 20 between the stopper 16 and those cables. Adequate void space must be available between the stoppers 14 and 16 and the tube 12 and between the stopper 16 and cables in the holes 20 for location of the binder materials in every event.

Referring to Figs. 2 and 3, the reference numeral 30 refers, in general, to a sealed splice closure formed by the splice closure apparatus 10 of Fig. 1. The sealed splice closure 30 accommodates cables 32 and 34, which pass through the holes 20 of the stopper 16 and into a void space 12c within the tube 12. The stoppers 14 and 16 are bonded with the tube 12 and the binders 18a and 18b at the first and second end portions 12a and 12b, respectively. The cables 32 and 34 are conventional cables of the type comprising low surface energy outer jackets 32a and 34a, respectively, and conductor elements 32b and 34b, respectively. As previously mentioned, the terms "conductor" and "conductor elements" are used to refer herein to not only electrical conductors, but also to any and all other materials and paths for communication, such as optical fibers and others. In Fig. 2, the outer jackets 32a and 34a of the cables 32 and 34, respectively, are removed and expose the conductor elements 32b and 34b, respectively, within a void space 12c within the tube 12 between the stoppers 14 and 16 as so bonded. A splice 36 connects the conductor elements 32b and 34b within the void space 12c.

The low surface energy outer jackets 32a and 34a of the cables 32 and 34, respectively, are bonded with the binders 22 and the stopper 16 within the holes 20 of the stopper 16. The bonding of the stoppers 14 and 16 with the tube 12 via the binders 18a and 18b and the bonding of the outer jackets 32a and 34a of the cables 32 and 34 with the stopper 16 via the binders 22 seals the splice 36 within the sealed splice closure 30. The bonding includes a fusing of materials of the stoppers 14 and 16, the binders 18a and 18b, and the tube 12 and of the outer jackets 32a and 32b, the binders 22, and the rubber stopper 16. An effective seal of the splice 36 and conductor elements 32b and 34b from

conditions outside the sealed splice closure 30 is, thus, presented.

Referring to Fig. 4, a suitable material for the binders 18a, 18b, and 22 includes susceptor materials, such as those disclosed in greater detail in U.S. Patent Application Ser. No. 08/412,966, filed March 29, 1995, entitled "Electromagnetic-Power-Absorbing Composite", assigned to the same assignee of the present invention and incorporated herein by this reference. As disclosed in that patent application, an electromagnetic-power-absorbing composite comprises a plurality of multilayered flakes dispersed in a binder agent. The binder agent is any of a variety of suitable polymers or polymer blends, such as thermoplastic polymers, thermoplastic elastomers, and thermally activated or accelerated cure polymers, or a polymeric or nonpolymeric adhesive. The multilayered flakes may include at least one layer pair comprising one thin film crystalline ferromagnetic metal layer 40 adjacent to one thin film dielectric layer 42. The multilayered flakes may be dispersed in a binder composition. In any event, the binder composition is generally acted upon physically and/or chemically by heat generated within the composite due to the interaction of electromagnetic power with the multilayered flakes. The composite material described is suitable for the binders 18a, 18b, and 22. Equipment for providing the electromagnetic power to perform induction bonding to form the sealed closure with the foregoing composite material as the binder is disclosed, for example, in U.S. Patent Application Ser. No. 08/413,119, filed March 29, 1995, titled "Induction Heating System for Fusion Bonding", assigned to the same assignee of the present invention and incorporated herein by this reference.

As is apparent from the foregoing description of bonding of the stopper 16 with the binders 22, a polymeric material, such as polyethylene, is bonded with rubber. This bonding is, in fact, the result of a diffusion of the polymeric materials into the interstices between the rubber molecules. As was earlier mentioned, bonding of polymeric materials to rubber has previously not been suitable. With use of susceptor materials in the polymer material, however, heat for achieving the bonding can be generated directly at the interface of the polymer material and the rubber. In addition to the heat generation, pressure is applied to, in effect, drive the polymer material into the interstices of the

rubber. Thus, with interfacial heating and application of pressure a suitable bond of the polymeric material to rubber is obtained.

Referring to Fig. 5, the reference numeral 300 refers, in general, to a method for implementing the sealed splice closure 30 of Fig. 2. In step 301, the binders 22 are wrapped around the cables 32 and 34. In step 302, the cables are pushed through the holes 16a and 16b until the cables 32 and 34 with the binders 22 are each disposed entirely within the rubber stopper 16. In step 304, an oscillating magnetic field is directed toward the binders 22, which field is generated by a radio frequency power source (not shown). The oscillating magnetic field causes the binders 22 to heat up and fuse (i.e., bond) the rubber stopper 16 and the outer jackets 32a and 34a of the cables 32 and 34. In step 306, the end portions of the conductor elements 32b and 34b are spliced together, as described above.

In step 308, the binders 18a and 18b are tacked to the inside surface of the respective end portions 12a and 12b of the tube 12. In step 310, the stoppers 14 and 16 are pressed into the respective end portions of the tube 12 until the stoppers are aligned with the binders 18a and 18b and the spliced end portions of the conductor elements 32b and 34b are enclosed within the void space 12c between the stoppers. In step 312, an oscillating magnetic field is directed toward the binders 18a and 18b, which field is generated by a radio frequency power source (not shown). The field causes the binders 18a and 18b to heat up and fuse (i.e., bond) the rubber stoppers 14 and 16, the binders 18a and 18b, and the tube 12. It should be noted that the step 304 may be combined with the step 312.

An example of the method 300 follows:

Two holes were cut (with a #6 hole borer) roughly on each side of the center of a number 5 size one (1) inch length solid rubber stopper. A ten inch length of telecommunication two pair buried service wire cable (S x 92-05-224 P BSWF) was bent in half and a one inch strip of "susceptor composite binder strip" (0.015 inch thick low density polyethylene strip containing 2.5% "susceptor composite flakes" -J321 experimental production run) was tacked on each leg of the cable about two and one half inches from the bend using a soldering gun. The cable legs containing the "susceptor composite binder

strips" were then pushed through the two holes in the rubber stopper until the "susceptor composite binder strips" were entirely within the rubber stopper. The rubber stopper was bonded to the cables by heating the "susceptor composite flakes" with an oscillating magnetic field from a radio frequency power source (power of about 75 to 100 watts). Hand pressure could not remove the cables.

A one half inch strip of the "susceptor composite binder strip" was then tacked on the inside (about one quarter inch from one end) of a five inch yellow polyethylene tube (pipe) (0.13 inch wall thickness, 1.04 inch inside diameter). The stopper bounded to the cables was then pressed into the end of the polyethylene tube containing the "susceptor composite binder strip" so the stopper was firmly within the pipe. A field from a radio frequency power source (99 MHz frequency) was used as before by placing the "tip antenna" over the tube and the "susceptor composite binder strip", resulting in a distinct circular bulge around the outside of the tube above the stopper.

After cooling, a heat shrink sleeve equipped with an air fitting was placed over the open end of the tube and pressurized at fifteen (15) pounds per square inch of air pressure and submerged in a water tank. The assembly remained under pressure for twenty four (24) hours without any leaks. After a one quarter inch cross section was cut from the raised portion of the tube, hand pressure could not separate the tube from the rubber stopper.

The example shows that a rigid closure was prepared that formed a permanent air and water tight bond between the rubber stopper and both the plastic tube and cable jackets. Additional environmental protection could be provided around the actual spliced conductors and splicing connectors and modules by a gel blanket or gel wrap or gel tape. After the gel blanket or tape is wrapped around the spliced area and confined with an elastic membrane (e.g., Easy wrap) or a rubber or a plastic tape, then the rigid splice closure is applied as described above.

Another example of the method 300 follows:

Two twenty five (25) feet sections of telecommunication two pair buried service wire cables (S x 92-05-224 P BSWF) were each bonded to a two hole rubber stopper (tapered end toward splice), leaving enough cable at each end to

be spliced together using 3M Discrete Connectors available from the Minnesota Mining and Manufacturing Company, St. Paul, Minnesota ("3M"), and a 3M 4484 Service Wire Shield Bond connector in a butt splice (cables are aligned with their ends side-by-side in the same direction and spliced). The spliced area was then wrapped with a gel strip and tightly compressed with rubber tape. One half inch strips of the "susceptor composite binder strips" was then tacked on the inside (about one quarter inch in from both ends) of a six inch yellow polyethylene tube (pipe) (0.12 inch wall thickness, 1.04 inch inside diameter). The gel strip covered splice and the stopper bonded to the cables was then pressed into one end of the polyethylene tube containing the "susceptor composite binder strip" so that the stopper was firmly within the tube. A solid number 5 stopper without any holes was firmly pressed within the other end of the tube containing the second "susceptor composite binder strip", thus enclosing the splice within the tube.

A field from a radio frequency power source was used by placing the "tip antenna" first over one end and then the other end of the tube and the "susceptor composite binder strip", resulting in a circular bulge around the outside of the tube above each stopper. Hand pressure could not remove the stoppers or cables.

Referring to Fig. 6, a sealed splice closure 410 includes a tube 412 having first and second end portions 412a and 412b, respectively. The tube 412 has an inside diameter of adequate size to accommodate cables 420 and 422, such as telecommunications or electronics cables, for example, at a splice. The tube 412 is formed of a material that is impenetrable by environmental effects and conditions and that is capable of housing the cables 420 and 422. An example of the tube 412 is a rigid, low density, polyethylene tube, having a low melting point, such as, for example, a polyethylene pipe, although other materials and shapes can be substituted.

First and second stoppers 414 and 416 are provided for insertion into the first and second end portions 412a and 412b, respectively, of the tube 412. The first and second stoppers 414 and 416 are each generally conical-shaped with flat ends 414a and 414b, and 416a and 416b, respectively. The flat ends 414b and 416b of the first and second stoppers 414 and 416, respectively, are smaller

than the internal diameter of the tube 412. The flat ends 414a and 416a of the first and second stoppers 414 and 416, respectively, are larger than the internal diameter of the tube 412. The longitudinal lengths of the stoppers 414 and 416 between the flat ends 414a and 414b and the flat ends of 416a and 416b, respectively, are sufficient that the stoppers 414 and 416 may be pressed an adequate distance, for example, about 0.5 to about 6 inches, into the tube 412 at the end portions 412a and 412b, respectively, to retain the stoppers 414 and 416 positioned partially within the end portions 412a and 412b.

The stoppers 414 and 416 each have a hole 414c or 416c, respectively, extending longitudinally therethrough. The holes 414c and 416c have diameters of adequate size to accommodate the cables 420 and 422, respectively. The stoppers 414 and 416 are conventional and are formed of conventional materials, for example, rubber, such as ethylene/propylene diene monomers (EPDM), Santoprene™, including polypropylene/EPDM or polypropylene/butyl rubber, or other materials which are adequately bondable and provide adequate sealing and resilience upon bonding as herein later described. The holes 414c and 416c of the stoppers 414 and 416 may be formed during molding or machining, as the case may be, of the stoppers 414 and 416, or may be drilled or otherwise bored in a solid stopper.

The splice closure 410 also includes binders 432, 433, and 434. The binders 432, 433, and 434 are comprised of materials that serve to bondingly seal adjacent parts of the splice closure 410. For example, the binders 432, 433, and 434 may comprise susceptor materials substantially similar to those described above with respect to the binders 18a, 18b, and 22 or other bondable materials. The binders 432, 433, and 434 are folded into cylindrical rings and placed into the tube 412 between the tube 412 and the stoppers 414 and 416, as is to be the case with the binders 432 and 433, respectively, and placed into the holes 414c and 416c, as is to be the case with the binders 434. As hereinafter detailed, the binders 432 and 433 encircle the cables 420 and 422 when placed within the holes 414c and 416c between the stoppers 414 and 416 and the cables 420 and 422. Adequate void space must be available between the stoppers 414 and 416 and the tube 412 and between the stoppers 414 and 416 and the cables 420 and 422 in the holes 414c and 416c for location of the binder materials in

every event.

The splice closure 410 accommodates the cables 420 and 422, which pass through the holes 414c and 416c, respectively, into a void space 412c within the tube 412. The cables 420 and 422 each comprise one or more respective conductors 424 and 426 which are partially sheathed in respective jackets 428 and 430. The cables 420 and 422 are inserted through the respective holes 414c and 416c until the cables extend into the void space 412c. The conductors 424 and 426 define end portions 424a and 426a, respectively, which extend into the void space 412c and are not sheathed in the jackets 428 and 430, respectively. Although not shown in detail in the Figure, the conductor end portions 424a and 426a are spliced together in an appropriate and typical manner. For example, the end portions 424a and 426a may be spliced together using 3M Modules in an in-line splice 431, wherein the cables 420 and 422 are aligned and spliced with their ends in opposite directions.

Referring to Fig. 7, the reference numeral 600 refers, in general, to a method for implementing the sealed splice closure 410. In step 601, the binders 432 and 433 are wrapped around the cables 420 and 422. In step 602, the holes 414a and 416a are formed in the respective rubber stoppers 414 and 416, and the cables 420 and 422 are pushed through the holes 414a and 416a until the binders 432 and 433 are within the holes 414a and 416a, respectively, and surround the cables 420 and 422 in the holes 414a and 416a. In step 604, an oscillating magnetic field generated by a radio frequency power source is directed toward the binders 432 and 433. The oscillating magnetic field causes the binders 432 and 433 to heat up and fuse (i.e., bond) the rubber stoppers 414 and 416, the binders 432 and 433, and the cable jackets 428 and 430, respectively. In step 606, the end portions 424a and 426a of the conductors 424 and 426 are spliced together.

In step 608, the two binders 434 are tacked to the inside surface of the end portions 412a and 412b of the tube 412. In step 610, the stoppers 414 and 416 are pressed into the respective end portions of the tube 12 until the stoppers 414 and 416 engage the binders 434 and the spliced end portions 424a and 426a are enclosed within the splice chamber 412c between the stoppers 414 and 416. In step 612, the binders 434 are exposed to an oscillating magnetic field

generated by a radio frequency power source. The oscillating magnetic field causes the binders 434 to heat up and fuse (i.e., bond) the binders 434, the tube 42, and the rubber stoppers 414 and 416 at each end of the tube 412.

An example of the method 600 follows:

Two eighteen (18) inch sections of fifty (50) pair telecommunications cable (SEAL PIC S x 0194) were each bonded to a separate number 7 size rubber stopper (tapered end toward splice), leaving enough cable at the end to be spliced together through 3M Modules in an inline splice (cables are aligned with each end in the opposite direction and spliced). Hand pressure could not remove the cables from the rubber stopper after using electromagnetic bonding of the rubber stoppers to the cable sheath. Then, one half inch strips of "susceptor composite binder strips" were tacked on the inside (about one quarter inch in from each end) of a twelve (12) inch white polyethylene tube (pipe) (0.13 inch wall thickness, 1.40 inch internal diameter). The pipe was then slid over the two stoppers so that each end of the pipe containing the "susceptor composite binder strip" was over the rubber stopper bonded to the cable sheath. A field from a radio frequency power source (power of about 75 to 100 watts, 92 MHz frequency) was used by placing the "tip antenna" first over one end and then the other end of the tube and the "susceptor composite binder strip", resulting in a slight depression around the outside of the tube above each stopper. Hand pressure could not remove the stoppers or cables from the tube.

Referring to Figs. 8 and 9, a sealed splice closure 710 (Fig. 9) includes a foam tube 712, such as a rubbery foam closed cell air conditioning tube, for example, such a tube manufactured by Rubatex and identified by Rubatex as part number R-180-FS, having 5/8 inch ID and a 3/8 inch wall thickness, and first and second end portions 712a and 712b, respectively. The tube 712 could, however, comprise any suitable thermoplastic, such as, for example, low-density polyethylene or ethylene/alpha-olefin copolymer, tube or pipe, cut to a desired length. The tube 712 is, furthermore, sized to receive two (or one or more) cables therein.

The splice closure 710 also includes binders 720 and 722, for example, comprised of materials substantially similar to those materials of which the

binders 18a, 18b, and 22 are comprised, as described with respect to Fig. 1 above. As shown in Fig. 9, a molded plastic end seal plug 718 is provided for fitting into the second end 712b of the tube 712. Tape 713, for example, conventional electrical tape, such as 3M all-weather vinyl tape or 3M EPR (ethylene propylene rubber) Tape, is also provided to secure each end 712a and 712b for bonding and for supporting the central portion thereof.

The splice closure 710 can accommodate spliced cables, such as two cables 714 and 716, which cables may be spliced in any appropriate manner. For example, the cables 20 and 22 may be spliced in the manner described above with respect to Fig. 1, or other splice connectors, such as the 3M Scotchlok connectors 719 or others, or other typical splices and mechanisms may be used. The accommodation of the cables 714 and 716 in the closure 710 may be achieved by wrapping the cables in the binders 720, as shown in Fig. 8. The wrapped cables 714 and 716 are then pushed through the first tube end portion 712a into the tube 712, so that the splice is contained within the interior of the tube 712. The molded plastic end seal plug 718 is also wrapped with the binder 722 and press fitted into the second tube end portion 712b. The binders 720 and 722 are contained within the first tube end portion 712a and the second tube end portion 712b, respectively, as so wrapped in each case.

The entire tube 712 is tightly wrapped with the tape 713 to provide pressure at the end portions 712a and 712b and to increase support in the central portion of the tube 712. A copper sheath 726 is optionally placed around the cables 714 and 716.

The tube 712 is sealed by directing an oscillating magnetic field to the end portions 712a and 712b, thereby causing the binders 720 and 722 to heat up and fuse (i.e., bond) the tube 712, the binders 720 and 722, the cables 714 and 716, and the end seal plug 718.

Referring to Fig. 10, the reference numeral 1100 refers, in general, to a method for implementing the sealed splice closure 710. In step 1101, the cables 714 and 716 are spliced together, and, in step 1102, the spliced cables are wrapped in the binders 720 and 722 as described above with respect to the embodiment shown in Fig. 8. In step 1104, the cables are inserted into the first end portion 712a of the tube 712 until the binder 720 is aligned within the first

end portion 712a. In step 1106, the end plug 718 is wrapped in the binder 722, and, in step 1108, the end plug 718 is inserted into the second end portion 712b of the tube 712 until the binder 722 and the end plug 718 are aligned within the second end portion 712b. In step 1110, the binders 720 and 722 are, at the same or different times, exposed to an oscillating magnetic field generated by a radio frequency power source. The exposure causes the binders 720 and 722 to heat up and fuse (i.e., bond) the tube 712, the binder 720, and the outer jackets of the cables 714 and 716 at the first end portion 712a and the tube 712, the binder 722, and the end plug 718 at the second end portion 712b.

An example of the method 1100 follows:

Two 6-inch sections of one-quarter inch diameter twenty-two gauge telecommunication buried service wire cable (AT&T 5x 92-05-22 224P BSWP) were spliced using 3M Discrete Connectors and a 3M 4464 Service Wire Shield Bond Connector in a butt splice (cables aligned with their ends side-by-side in the same direction). Separately, an eight inch length of Rubatex (R-180-FS, 25/50 Rated RU 2072, RF-16, 5/8" ID x 3/8" wall) rubbery closed cell air conditioning tubing was used as the body of a closure by sliding the tube over the butt splice. A flexible film member insert part was prepared by placing a "susceptor composite binder strip" (9DHH 1 LAMP material) as a middle layer between low density polyethylene film (0.04 inch thickness, one-half inch wide) wrapped around the cables in one end of the foam tube. A small plastic plug, also wrapped with a piece of the flexible film member with a middle layer of "susceptor composite binder strip" was pushed up into the foam tube end which did not contain cables.

Finally, the entire foam tube was tightly wrapped with 3M all-weather vinyl tape to provide pressure at the ends and to increase support in the central portion. A field from a radio frequency power source (60 watts power at about 100 MHz frequency) was used by placing the tip antenna over first one end and then the other end of the foam tube above the "susceptor composite binder strips", causing the flexible film insert parts to melt, forming a sealing bond between the cable sheaths and the foam tube on one side and the plug and the foam tube on the other. The central portion of the foam tube served as a protective closure over the cable splice.

After cooling, heat shrink sleeves were placed over each end of the cables, with one sleeve equipped with an air fitting on the cable with the wire removed. The cable was pressurized with four (4) pounds per square inch and placed inside a water tank for three (3) days. Then, the pressure was increased to fourteen (14) psi for twenty four (24) hours. No leaks were detected.

Referring to Figs. 11 and 12, a sealed splice closure 1210 includes a pipe 1212 having first and second open ends 1212a and 1212b, respectively, and a central portion 1212c. The pipe 1212 may be formed from any suitable thermoplastic, such as, for example, low density polyethylene or ethylene/alpha-olefin copolymer tube or pipe. Two heat-shrinkable tubing sections 1214 and 1216, for example, of modified polychloroethylene or Neoprene, are provided for placement over the end portions 1212a and 1212b, respectively. A flexible film member insert 1213 comprising a low density polyethylene film is also provided.

The first open end portion 1212a accommodates the placement therein of the cables 1220 and 1222 spliced at the ends using splice connectors in the manner described above with respect to Fig. 1, or using other splice connectors, such as 3M Scotchlok connectors. The splice in the tube 1212 is sealed therein by placing the tubing sections 1214 and 1216 over the respective ends of the tube 1212 and directing heat from a conventional hot air blower (not shown) onto the first and second end portions 1212a and 1212b. The hot air causes the polyethylene of the end portion 1212a of the pipe 1212 to melt or soften and flow around the cables 1220 and 1222 and the polyethylene of the end portion 1212b to melt and flow together and seal the other end portion 1212a. The hot air also causes the heat shrink tube sections 1214 and 1216 to shrink and contract (i.e., collapse) the pipe around the cables 1220 and 1222, thereby creating a sealing bond as shown in Fig. 11. Hot air is not directed to the central portion 1212c of the pipe 1212, thereby permitting it to maintain its original shape.

Referring to Fig. 13, the reference numeral 1400 refers, in general, to a method for implementing the sealed splice closure 1210. In step 1401, the tubing sections 1214 and 1216 are placed over the pipe 1212. In step 1402, the cables 1220 and 1222 are spliced together, and, in step 1404, the spliced cables

are wrapped in the film insert 1213. In step 1406, the cables are inserted into the first end portion 1212a of the tube 1212 until the film insert 1213 is aligned within the first end portion 1212a. In step 1408, hot air is directed to the tubing sections 1214 and 1216 until the tubing sections 1214 and 1216 contract, and the tube 1212 melts and collapses at the tubing sections 1214 and 1216, sealingly forming the closure 1210.

An example of the method 1400 follows:

Two six (6) inch sections of three (3) pair twenty-two (22) gauge telecommunication cable (Superior 3 x 22-05/94) were held together with a 3M 4464 Shield Bond Connector in a butt configuration (cables are aligned with their ends side-by-side in the same direction) with one wire pulled from one cable to allow pressurized air to enter later. Separately, a pipe assembly was prepared by placing one (1) inch sections of 3M NST Tubing (modified polychloroethylene or Neoprene) of one and one quarter diameter (0.087 recovered wall thickness) over each end of a polyethylene pipe. A flexible film member insert comprised of low density polyethylene film (0.04 inch thickness, three-quarter inch wide, three and one half inches long) was wrapped tightly around the cables and pushed up into one end of the pipe assembly.

The end of the pipe was then bonded to the two cables (and the flexible film member insert) by using hot air from a heat gun (Steinel HL 1600 ME Heat Gun-type 3406/120V/60 Hz/1400 W) to cause the polyethylene from the pipe and the insert to melt or soften and flow around the cables and to shrink the heat shrink tube to apply pressure to cause contraction (collapse) of the pipe around the cables, forming a sealing bond. Applying hot air from the heat gun also caused collapse of the pipe on the other end and the pressure of the shrinking heat shrink tube provided a sealed bond. The central portion of the pipe does not soften and serves as a protective closure over the cables.

After cooling, heat shrink sleeves were placed over each end of the cables, with one sleeve equipped with an air fitting on the cable with the wire removed. The cable was pressurized with four (4) pounds per square inch and placed inside a water tank for three (3) days. Then the pressure was increased to fourteen (14) psi for twenty-four (24) hours without any leaks.

Although illustrative embodiments of the invention have been shown and

described, a wide range of modification, change, and substitution is contemplated in the foregoing disclosure and in some instances, some features of the present invention may be employed without a corresponding use of the other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the invention.

Claims

What is claimed is:

1. A sealed closure, comprising:

a tube having a first end and a second end;

a first stopper disposed in the first end, wherein the tube and the first stopper are bonded together by heat generated from a first binder interposed between the tube and the first stopper when the binder is exposed to an oscillating magnetic field;

a second stopper disposed in the second end and defining at least one hole extending longitudinally therethrough, wherein the tube and the second stopper are bonded together from heat generated from a second binder interposed between the tube and the second stopper when the binder is exposed to an oscillating magnetic field; and

at least two cables, each of which extends through one of the at least one holes, and which cables are electrically connected together in the interior of the tube between the first and second stoppers;

wherein the cables and the surfaces defining the holes are bonded together from heat generated from third binders interposed between the cables and the surfaces of the respective holes when the third binders are exposed to an oscillating magnetic field.

2. The closure of claim 1, wherein the first, second, and third binders comprise susceptor material.

3. The closure of claim 2, wherein the susceptor material comprises an electromagnetic-power-absorbing composite having a plurality of multilayered flakes dispersed in a binder agent, the binder agent being selected from the group consisting of thermoplastic polymers, thermoplastic elastomers, thermally activated polymers, thermally accelerated-cure polymers, polymeric adhesives, and nonpolymeric adhesives, wherein the multilayered flakes include at least one thin film crystalline ferromagnetic metal layer adjacent to one thin film dielectric layer.

4. A kit for sealing closures, comprising:

a tube having a first end and a second end;

a first stopper capable of being disposed in the first end of the tube;

a second stopper capable of being disposed in the second end of the tube, the second stopper defining at least two holes extending longitudinally therethrough such that at least two cables may be extended through the at least two holes and be electrically connected together in the interior of the tube; and

a plurality of binders capable of being interposed between the tube and the first stopper, between the tube and the second stopper, and between the surface of each of the at least two holes and the at least two cables extending through the at least two holes, such that upon exposure to an oscillating magnetic field, the binders generate sufficient heat to bond the tube to the first and second stoppers, and the cables to the surfaces of the holes through which the respective cables extend.

5. The closure of claim 4, wherein the binders comprise susceptor material.

6. The closure of claim 5, wherein the susceptor material comprises an electromagnetic-power-absorbing composite having a plurality of multilayered flakes dispersed in a binder agent, the binder agent being selected from the group consisting of thermoplastic polymers, thermoplastic elastomers, thermally activated polymers, thermally accelerated-cure polymers, polymeric adhesives, and nonpolymeric adhesives, wherein the multilayered flakes include at least one thin film crystalline ferromagnetic metal layer adjacent to one thin film dielectric layer.

7. A sealed closure, comprising:

a tube having a first end and a second end;

a first stopper disposed in the first end and defining at least one first hole extending longitudinally therethrough, wherein the tube and the first stopper are bonded together from heat generated from a first binder interposed between the tube and the first stopper when the binder is exposed to an oscillating magnetic field;

a second stopper disposed in the second end and defining at least one second hole extending longitudinally therethrough, wherein the tube and the second stopper are bonded together from heat generated from a second binder interposed between the tube and the second stopper when the binder is exposed to an oscillating magnetic field; and

at least one first cable extending through the at least one first hole, and at least one second cable extending through the at least one second hole, which at least one first and second cables are electrically connected together in the interior of the tube between the first and second stoppers, wherein the at least one first and second cables and the surfaces defining the respective at least one first and second holes are bonded together from heat generated from third binders interposed between the at least one first and second cables and the surfaces defining the respective at least one first and second holes when the third binders are exposed to an oscillating magnetic field.

8. The closure of claim 7 wherein the first, second, and third binders comprise susceptor material.

9. The closure of claim 8, wherein the susceptor material comprises an electromagnetic-power-absorbing composite having a plurality of multilayered flakes dispersed in a binder agent, the binder agent being selected from the group consisting of thermoplastic polymers, thermoplastic elastomers, thermally activated polymers, thermally accelerated-cure polymers, polymeric adhesives, and nonpolymeric adhesives, wherein the multilayered flakes include at least one thin film crystalline ferromagnetic metal layer adjacent to one thin film dielectric layer.

10. A kit for sealing closures, comprising:

a tube having a first end and a second end;

a first stopper capable of being disposed in the first end of the tube, the first stopper defining at least one first hole extending longitudinally therethrough such that at least one first cable is capable of being extended through the at least one first hole ;

a second stopper capable of being disposed in the second end of the tube, the second stopper defining at least one second hole extending longitudinally therethrough such that at least one second cable is capable of being extended through the at least one second hole and of being electrically connected to the at least one first cable in the interior of the tube; and

a plurality of binders capable of being interposed between the tube and the first stopper, between the tube and the second stopper, and between the surface of each of the at least one first and second holes and the respective at least one first and second cables extending through the at least one first and second holes, such that upon exposure to an oscillating magnetic field, the binders generate sufficient heat to bond the tube to the first and second stoppers, and the at least one first and second cables to the surfaces of the respective at least one first and second holes.

11. The closure of claim 10, wherein the binders comprise susceptor material.

12. The closure of claim 11, wherein the susceptor material comprises an electromagnetic-power-absorbing composite having a plurality of multilayered flakes dispersed in a binder agent, the binder agent being selected from the group consisting of thermoplastic polymers, thermoplastic elastomers, thermally activated polymers, thermally accelerated-cure polymers, polymeric adhesives, and nonpolymeric adhesives, wherein the multilayered flakes include at least one thin film crystalline ferromagnetic metal layer adjacent to one thin film dielectric layer.

13. A sealed closure, comprising:

a tube having a first open end and a second open end;

at least two cables electrically connected together at a splice, wherein the cables are received into the first end of the tube such that the splice is within the interior of the tube, and wherein the tube and the at least two cables are bonded together from heat generated from a first binder wrapped around the cables and interposed between the cables and the tube when the binder is exposed to an oscillating magnetic field; and

a plug disposed in the second end, wherein the tube and the plug are bonded together from heat generated from a second binder interposed between the tube and the plug when the binder is exposed to an oscillating magnetic field.

14. The closure of claim 13, wherein the first and second binders comprise susceptor material.

15. The closure of claim 14, wherein the susceptor material comprises an electromagnetic-power-absorbing composite having a plurality of multilayered flakes dispersed in a binder agent, the binder agent being selected from the group consisting of thermoplastic polymers, thermoplastic elastomers, thermally activated polymers, thermally accelerated-cure polymers, polymeric adhesives, and nonpolymeric adhesives, wherein the multilayered flakes include at least one thin film crystalline ferromagnetic metal layer adjacent to one thin film dielectric layer.

16. A kit for sealing closures, comprising:

a tube having a first open end and a second open end;

at least two cables capable of being electrically connected together at a splice, and of being received into the first end of the tube such that the splice is within the interior of the tube, and wherein the tube and the at least two cables are capable of being bonded together from heat generated from a first binder wrapped around the cables and interposed between the cables and the tube when the binder is exposed to an oscillating magnetic field; and

a plug capable of being disposed in the second end, wherein the tube and the plug are capable of being bonded together from heat generated from a second binder interposed between the tube and the plug when the binder is exposed to an oscillating magnetic field.

17. The closure of claim 16, wherein the first, second, and third binders comprise susceptor material.

18. The closure of claim 17, wherein the susceptor material comprises an electromagnetic-power-absorbing composite having a plurality of multilayered flakes dispersed in a binder agent, the binder agent being selected from the group consisting of thermoplastic polymers, thermoplastic elastomers, thermally activated polymers, thermally accelerated-cure polymers, polymeric adhesives, and nonpolymeric adhesives, wherein the multilayered flakes include at least one thin film crystalline ferromagnetic metal layer adjacent to one thin film dielectric layer.

19. A sealed closure comprising:

a pipe having a first open end and a second open end;

at least two cables electrically connected together at a splice, wherein the cables are received into the first end of the pipe such that the splice is within the interior of the pipe, and wherein the cables are wrapped in a flexible film member at the interface between the cables and the pipe;

first and second heat-shrink tube portions fitted over the respective first and second ends of the pipe;

wherein the flexible film member, the first and second pipe ends, and the first and second tube portions and bonded together, and the void space is sealed, from the application of heat thereto.

20. The closure of claim 19, wherein the flexible film member is a low density polyethylene film.

21. The closure of claim 19, wherein the first and second tube portions comprise materials selected from the group consisting of polychloroethylene and Neoprene.

22. A kit for sealing closures, comprising:

a pipe having a first open end and a second open end;

at least two cables capable of being electrically connected together at a splice, wherein the cables are capable of being received into the first end of the pipe such that the splice is within the interior of the pipe, and wherein the cables are capable of being wrapped in a flexible film member at the interface between the cables and the pipe;

first and second heat-shrink tube portions capable of being fitted over the respective first and second ends of the pipe; and

wherein the flexible film member, the first and second pipe ends, and the first and second tube portions are capable of being bonded together, and the void space is sealed, from the application of heat thereto.

23. The closure of claim 22, wherein the flexible film member is a low density polyethylene film.

24. The closure of claim 22, wherein the first and second tube portions comprise materials selected from the group consisting of polychloroethylene and Neoprene.

25. A method of bonding polymeric material to rubber comprising the steps of:

placing the polymeric material in contact with the rubber so that there is a polymeric material/rubber interface;

heating the polymeric material/rubber interface; and

applying pressure to force the polymeric material towards the rubber.

26. The method of claim 25, further comprising the step of:

dispersing susceptor material in the polymeric material;

wherein the step of heating includes the step of oscillating a magnetic field in the vicinity of the susceptor material.

27. The method of claim 25, further comprising the steps of:

placing a resistive wire in the vicinity of the polymeric material in contact with the rubber; and

wherein the step of heating includes the step of providing current to the resistive wire.

28. The method of claim 25, wherein the step of applying pressure is performed by an elastomeric tube.

29. The method of claim 25, wherein the step of applying pressure includes the step of containing the polymeric material and the rubber within a confined space and expanding the polymeric material to create pressure within the confined space.

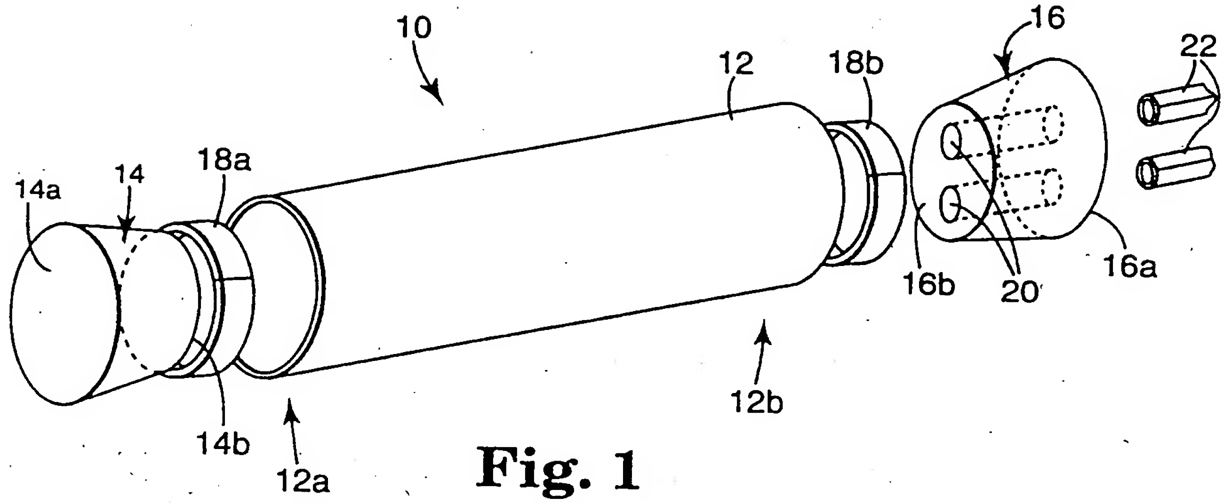
30. A system of bonding polymeric material to rubber, the polymeric material being in contact with the rubber so that there is a polymeric material/rubber interface, comprising:

means for heating the polymeric material/rubber interface; and

means for applying pressure to force the polymeric material towards the rubber.

31. The method of claim 30, wherein the means for heating comprises susceptor material dispersed in the polymeric material and a means for creating a magnetic field.

32. The method of claim 30, wherein the means for heating includes a resistive wire in the vicinity of the polymeric material in contact with the rubber.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12b

Fig. 1

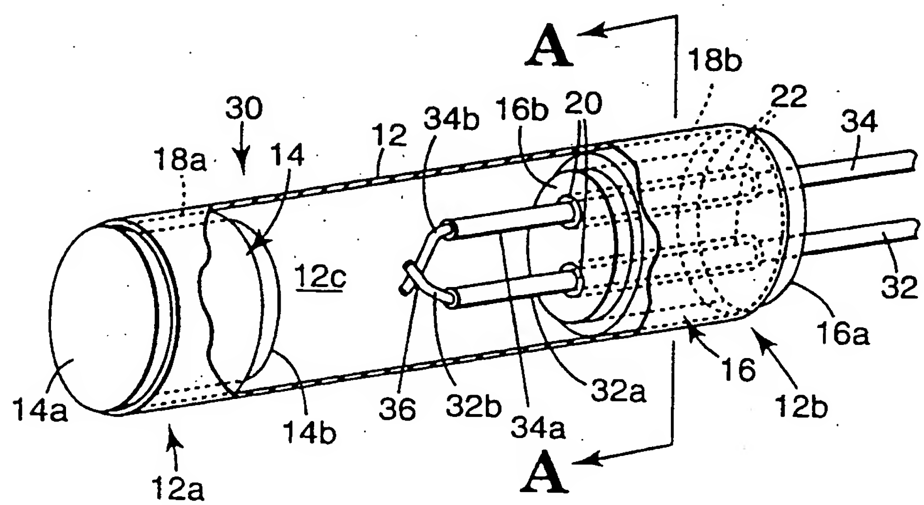
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Fig. 2

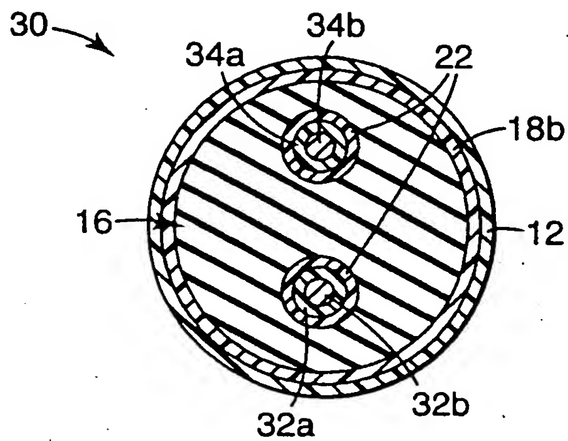

Fig. 3

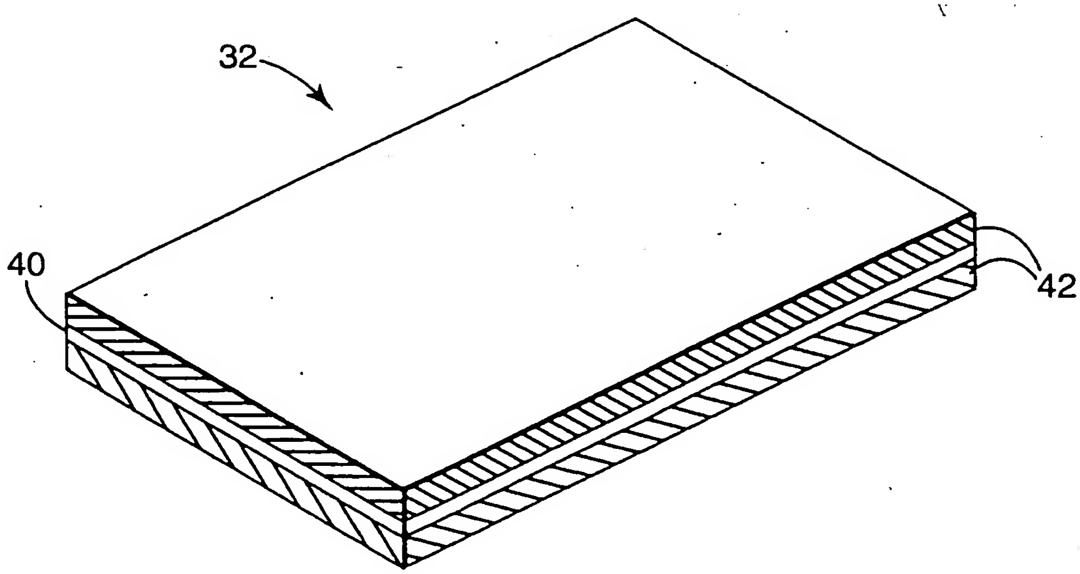

Fig. 4

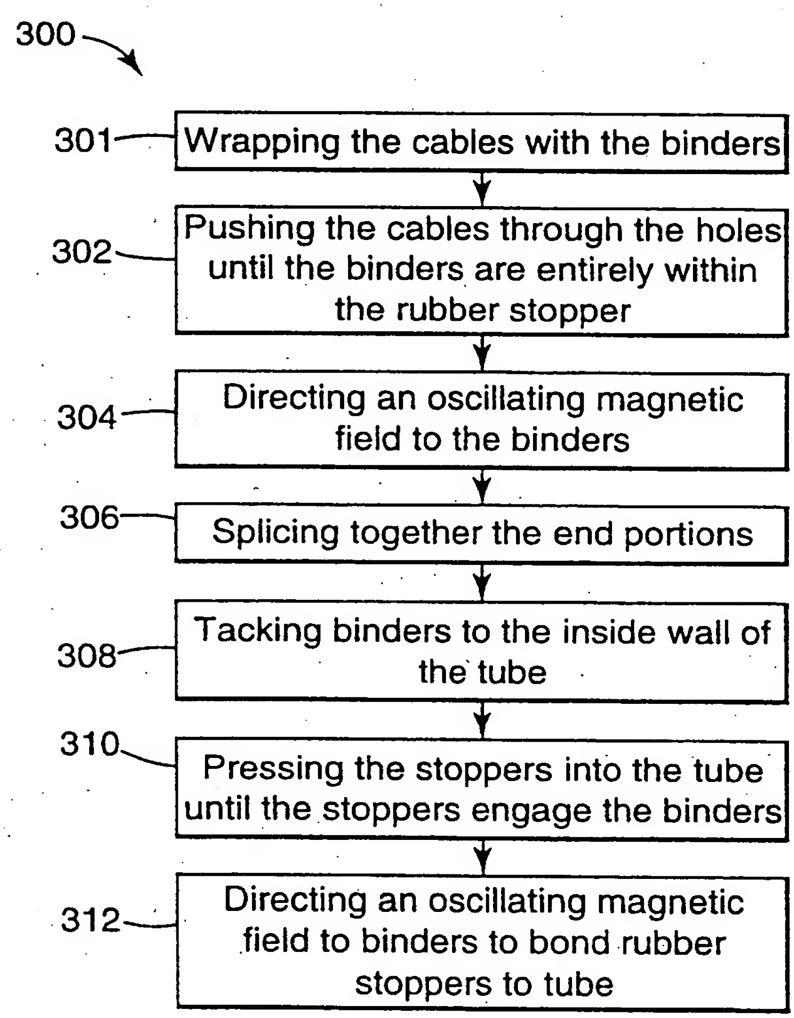
300
301 Wrapping the cables with the binders
302 Pushing the cables through the holes until the binders are entirely within the rubber stopper
304 Directing an oscillating magnetic field to the binders
306 Splicing together the end portions
308 Tacking binders to the inside wall of the tube
310 Pressing the stoppers into the tube until the stoppers engage the binders
312 Directing an oscillating magnetic field to binders to bond rubber stoppers to tube

Fig. 5

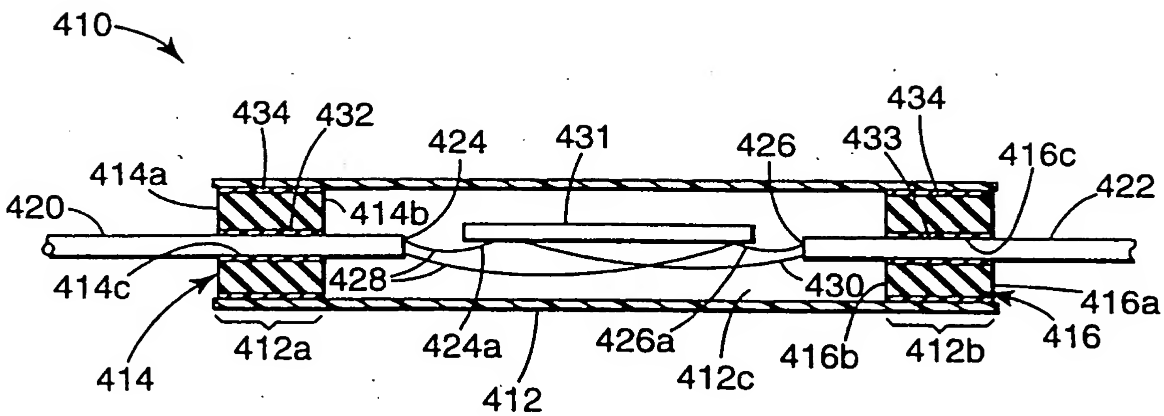
410
434
432
424
431
426
433
434
416c
414a
420
414b
422
414c
428
430
416a
412a
424a
426a
412c
416b
412b
416
414
412

Fig. 6

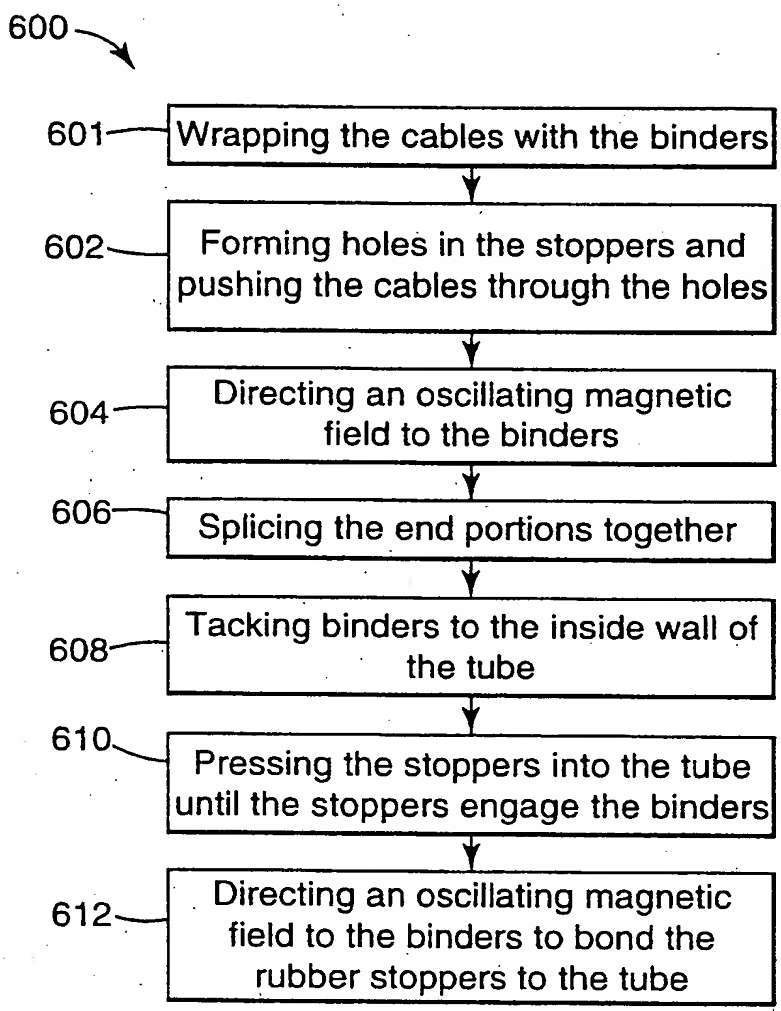
600
601
Wrapping the cables with the binders
602
Forming holes in the stoppers and pushing the cables through the holes
604
Directing an oscillating magnetic field to the binders
606
Splicing the end portions together
608
Tacking binders to the inside wall of the tube
610
Pressing the stoppers into the tube until the stoppers engage the binders
612
Directing an oscillating magnetic field to the binders to bond the rubber stoppers to the tube

Fig. 7

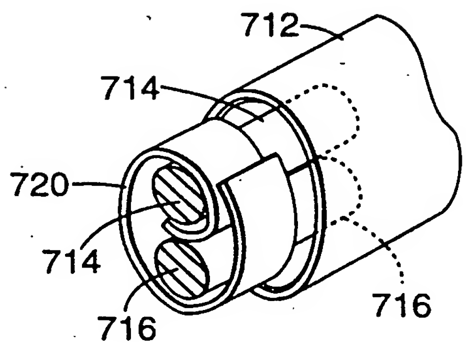
712
714
720
714
716
716

Fig. 8

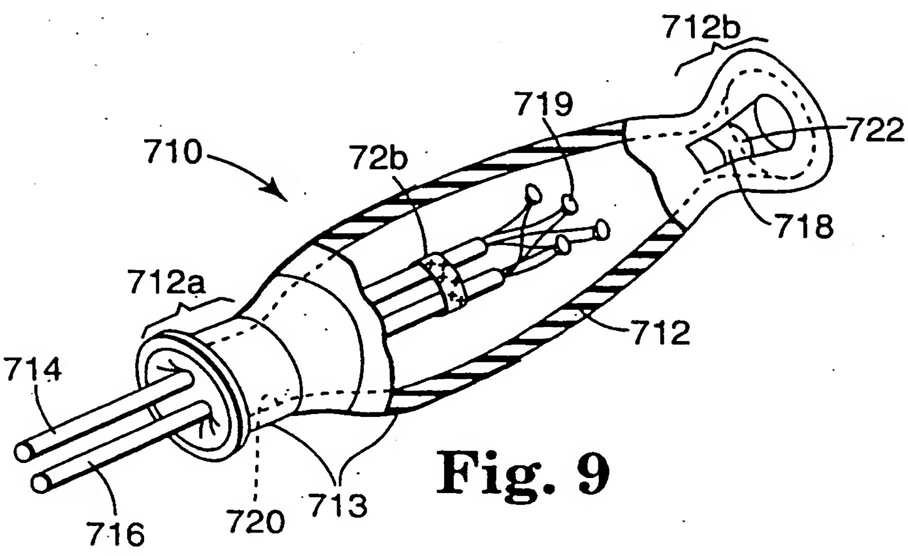
712b
719
722
710
72b
718
712a
712
714
716
720
713

Fig. 9

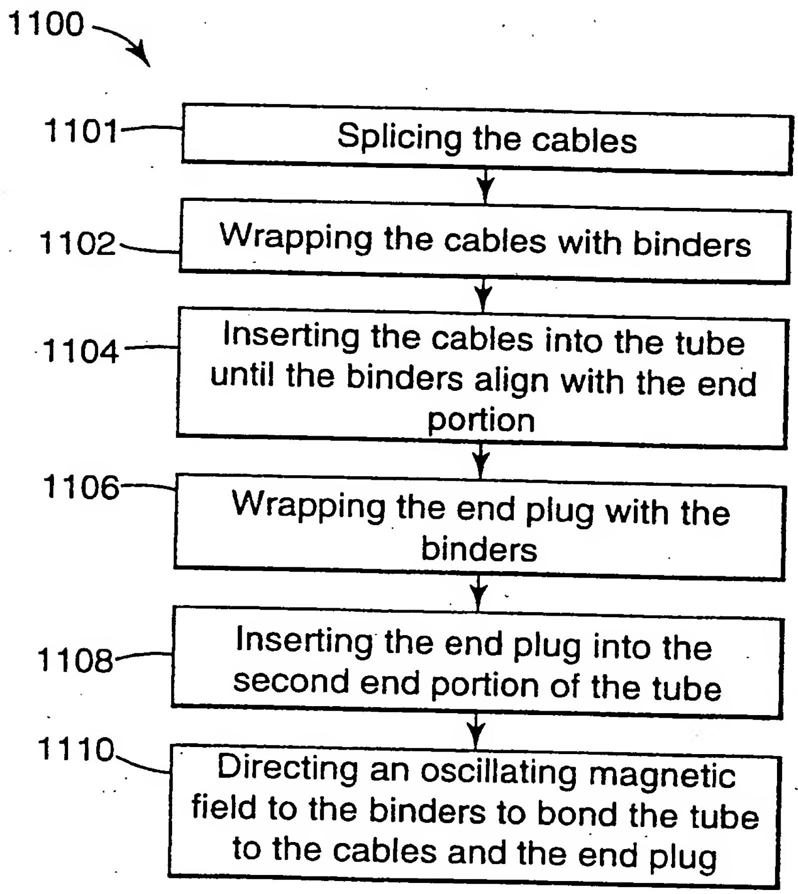
1100
1101
Splicing the cables
1102
Wrapping the cables with binders
1104
Inserting the cables into the tube until the binders align with the end portion
1106
Wrapping the end plug with the binders
1108
Inserting the end plug into the second end portion of the tube
1110
Directing an oscillating magnetic field to the binders to bond the tube to the cables and the end plug

Fig. 10

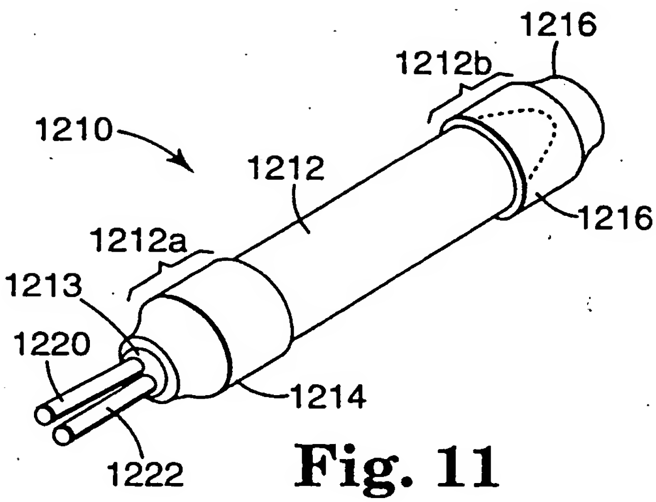
1216
1212b
1210
1212
1216
1212a
1213
1220
1214
1222

Fig. 11

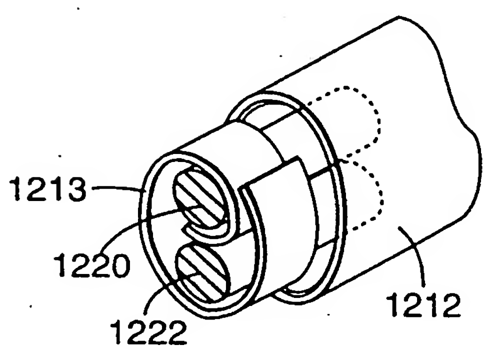
1213
1220
1212
1222

Fig. 12

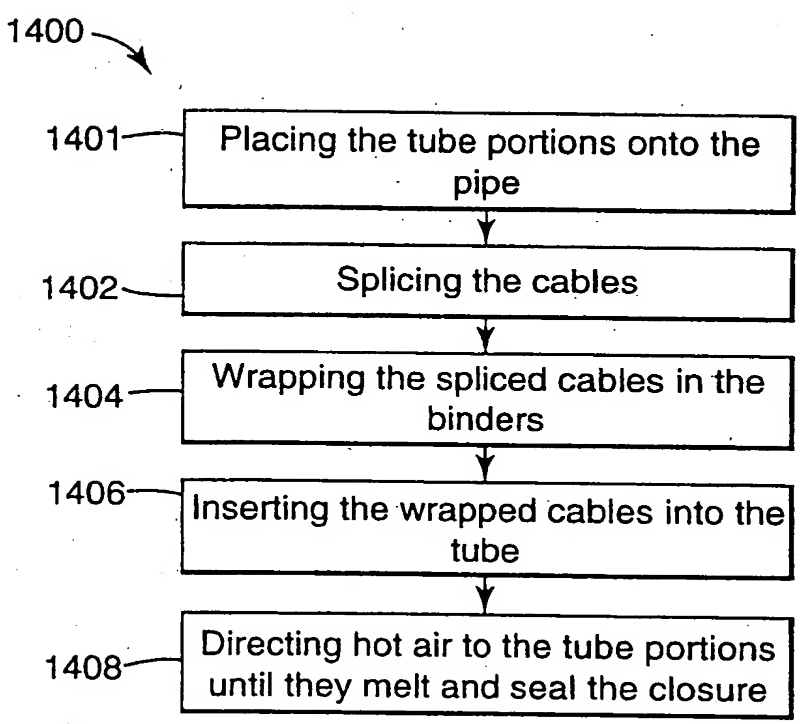
1400
1401
Placing the tube portions onto the pipe
1402
Splicing the cables
1404
Wrapping the spliced cables in the binders
1406
Inserting the wrapped cables into the tube
1408
Directing hot air to the tube portions until they melt and seal the closure

Fig. 13

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 97/03603

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H02G15/013 H02G15/192

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H02G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 93 10960 A (MINNESOTA MINING AND MANUFACTURING COMPANY) 10 June 1993 see page 4, line 10 - page 10, line 33; claims 1-18; figures 1-3	1-18
A	WO 96 31091 A (MINNESOTA MINING AND MANUFACTURING COMPANY) 3 October 1996 cited in the application see the whole document	1-18
A	WO 96 31090 A (MINNESOTA MINING AND MANUFACTURING COMPANY) 3 October 1996 cited in the application see page 5, line 27 - page 7, line 25	1-18
A	EP 0 102 187 A (RAYCHEM) 7 March 1984 see page 16, line 18 - line 21; figure 5	19,22

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
18 July 1997	30.07.97

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Lommel, A

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 97/03603

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 979 833 A (STANDARD TELEPHONES AND CABLES) 26 July 1963 see the whole document ---	19,22
A	EP 0 488 895 A (SILEC) 3 June 1992 see abstract; figures 1,2 -----	19,22

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 97/03603

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